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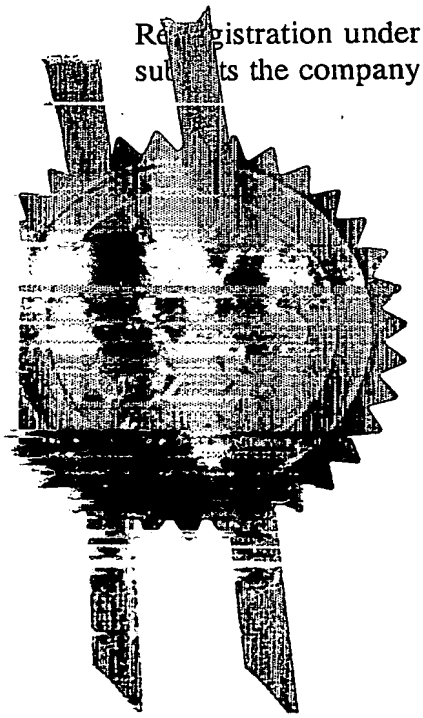

Signed J Evans.

Dated 3 October 2003

Patents Form 1/77

The Patent Office

1/77

138EP02 E747858-1 D02136
P01/7700 0.00-0221150.6

THE PATENT OFFICE
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(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
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1. Your reference: RJ/GM/N12786

2. Patent application number *(The Patent Office will fill this part)*: 0221150.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

MATTHEWS, Siobhan Olive & MATTHEWS, John
Unit 26, Regional Development Centre
Dundalk Institute of Technology, Dublin Road
Dundalk, Ireland

Patents ADP number *(if you know it)*: 8464109001 8464547001

If the applicant is a corporate body, give the country/state of its incorporation:

4. Title of the invention: INCORPORATION OF FUNCTIONAL MATERIALS INTO BULK MATERIALS

5. Name of your agent *(if you have one)*
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*:

Williams Powell
4 St. Paul's Churchyard
London
EC4M 8AY

Patents ADP number *(if you know it)*: 5830310001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority appliation number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earleir UK application, give the number and the filing date of the earlier application.

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(answer 'Yes if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

NO

9. Enter the number of sheets for any of the following items you are sending with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	4
Claim(s)	1
Abstract	
Drawing(s)	2 + 2

10. If you are filing one of the following, state how many against each item.

Priority documents	
translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/we quest the grant of a patent on the basis of this application.

Signature [signature] Date 12/09/02

12. Name and daytime telephone number of person to contact in the United Kingdom Mr Lee Anderson 020 7329 4400

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INCORPORATION OF FUNCTIONAL MATERIALS INTO BULK MATERIALS

The present invention relates to a method of and apparatus for incorporating functional materials into bulk material systems.

A functional material is a material that has the ability to perform a specific function or a number of functions. By incorporating a functional material into bulk materials the resultant material system can have the ability to undertake the specific function or functions without adversely affecting the original properties of the bulk material. Therefore, bulk materials, both inorganic and organic such as polymers, ceramics, metals and wood, can be processed in such a way that functional materials can be incorporated into the matrix.

Conventional materials processing facilitates the incorporation of materials such as fillers into a matrix material at a macroscopic level. A variety of methods can be employed but for bulk processing dry mixing of the filler and the bulk material and in-situ melt mixing of the filler are common techniques. These fillers might be chosen, for example, to enhance the mechanical properties of the matrix material. However, these fillers might affect the aesthetic properties or the anisotropy of the matrix material or the material system. Furthermore, if the distribution is not efficient, the function of the filler might not be effective. To date, the incorporation of functional materials into bulk systems other than for mechanical enhancement, to reduce material cost or to provide aesthetic qualities is rare.

United States patent no. 5,508,060 describes a method for polymer impregnation for a batch process. No bulk material processing technique enabling the addition of materials at a nanoscale or near nanoscale level has been reported.

The present invention seeks to provide an improved method and system for incorporating functional materials into bulk materials.

According to an aspect of the present invention, there is provided a method of incorporating into a bulk material a functional material, including the steps of dissolving at least one functional material, in part or in full, in a fluid, which fluid is near or in the supercritical fluid state, and adding the solution of functional material into a bulk material provided in a semi-solid or molten state.

Advantageously, dissolution of the functional material or materials can be provided with the supercritical fluid or near supercritical fluid acting as a solvent and may include

entrainers, co-solvents, ligands and other binding agents such as enzymes and receptors.

Preferably, the method also includes the step of maintaining the system above a predetermined temperature or pressure.

The preferred embodiment adds sufficient fluid in the near or supercritical state to allow the dissolution of the functional material in the fluid. The preferred embodiment includes means for controlling the amount of functional fluid/solution that is incorporated into the bulk material.

Thus, in the preferred embodiment, functional materials can be dissolved into supercritical and near supercritical fluids and the "mixture" then formed is then incorporated into the bulk material during processing. A typical process would involve a polymer processing based technique such as injection moulding or extrusion. Examples of supercritical fluid assisted processing, without the impregnation of functional materials, is described in the British Patent Application No.0030182.0. During processing the functional material solution dissolves into the bulk material. Altering the solution conditions such as temperature and pressure facilitates precipitation of the functional material from the solution.

The supercritical or near supercritical fluid can be recycled and used again or can be vented to atmosphere.

One suitable fluid is carbon dioxide but the invention is not limited to this fluid. other fluids such as water and nitrogen could be used.

According to another aspect of the present invention, there is provided apparatus for incorporating into a bulk material a functional material, including means for providing at least one functional material, means operable to provide a fluid at a supercritical or near supercritical state, means for dissolving, in part or in full, said at least one functional material in said fluid, and means operable to add the solution of functional material into a bulk material provided in a semi-solid or molten state.

The preferred embodiment uses provides a processing technique which can be incorporated into conventional processes, for example polymer-based processing such as extrusion and injection moulding, to manufacture products with functional applications. The preferred embodiments can provide a clean, efficient and environmentally friendly method for the incorporation of functional materials of the types outlined above and other functional materials which can impart useful properties to the matrix material, such as to

transmit and/or receive electrical, microwave and radio wave signals. The absorption and/or the transmission of energy from the electromagnetic spectrum, sound energy, an electrical charge and heat or the bulk material to act as a chemical or biological sensor can also be accomplished using the techniques disclosed herein, as they can provide a new method for the incorporation of functional materials into the bulk material system.

It is known that supercritical fluids such as supercritical carbon dioxide act as tuneable solvents and provide a clean and efficient method for the extraction of components from bulk materials such as soil remediation and the decaffeination of coffee.

Embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows one embodiment of system for incorporating into a bulk material one or more functional materials; and

Figure 2 shows another embodiment of system for incorporating into a bulk material one or more functional materials.

Functional materials can be used for micro-devices, data storage, light emitting diodes, photovoltaic cells, fuel cells, batteries and tissue engineering applications as it is possible to enhance the electrical, optical, magnetic, mechanical, energy transfer, chemical sensory properties of bulk materials using this new technology. The teachings herein enable conventional processing equipment to shape complex functional parts and improve on the present small batch scale production limitations.

Figure 1 outlines one embodiment of system. The functional material 1 and the fluid 2 are transferred separately to a pump capable of achieving high pressures 3. In this embodiment, the pump used is an ISCO 260D syringe pump (obtainable from ISCO Inc., Nebraska, USA). Using carbon dioxide as an example under the correct operating conditions of pressure and temperature, the fluid reaches its supercritical or near supercritical state dissolving the functional material (850 to 5000 psi and from 30°C. This functional solution is then injected into a pressure chamber 4 for semi-solid impregnation or polymer processing equipment 5 for melt processing.

Figure 2 outlines another embodiment of system. The functional material 1 is [illegible] or part dissolved in the fluid 2. This solution or part mixture is transferred to a pump capable of achieving high pressures 3. The pump used in this embodiment is an ISCO 260D syringe pump (ISCO Inc., Nebraska, USA). Using carbon dioxide as an

example under the correct operating conditions of pressure and temperature the fluid reaches it's supercritical or near supercritical state dissolving the functional material (850 to 5000 psi and from 30°C0. This functional solution is then injected into a pressure chamber 4 for semi-solid impregnation or polymer processing equipment 5 for melt processing.

The functional material is soluble in a near supercritical or supercritical fluid, which dissolves in the matrix material. Alternation of the processing conditions facilitates a change of state for the fluid, which results in the precipitation of the functional material in the bulk material. This method allows the shaping of the impregnated bulk material using conventional polymer based processing techniques such as extrusion and injection moulding.

In some embodiments the functional material could aid the removal of certain unwanted materials after bulk processing. For example a material formulation might be used to facilitate shaping of components but is not required after shaping or it could be detrimental to the success of additional processing steps that are required. In another example the removal of a material after processing would enhance the formation of an open porous or interconnected network. The functional material could also aid the removal of unwanted materials that are used to enhance processing or are present as a result of processing (processing by-products), without such removal overall properties of the finished product could be affected. In all cases this type of functional material will increase the efficiency of extraction.

Figure 1

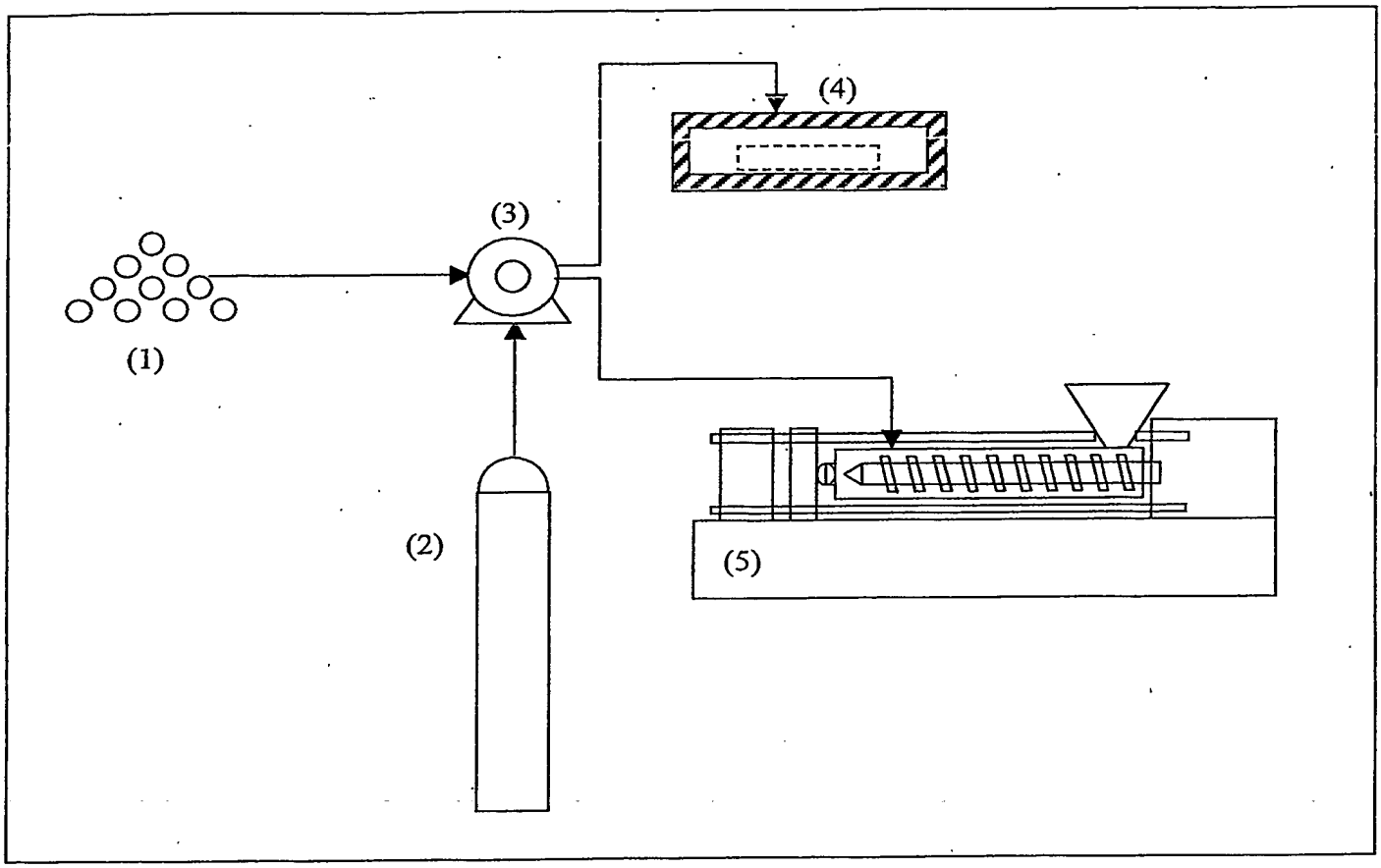
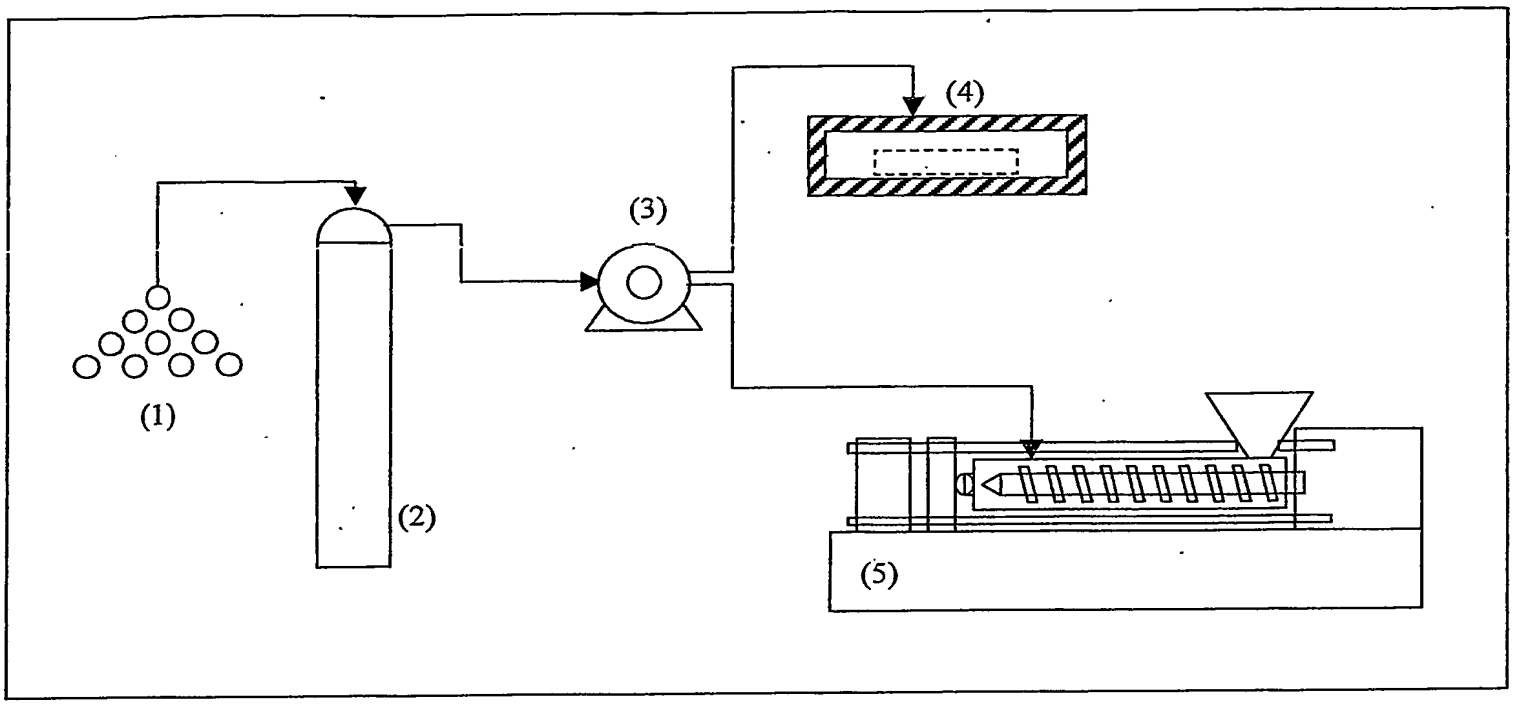


Figure 2



PCT Application

GB0303964